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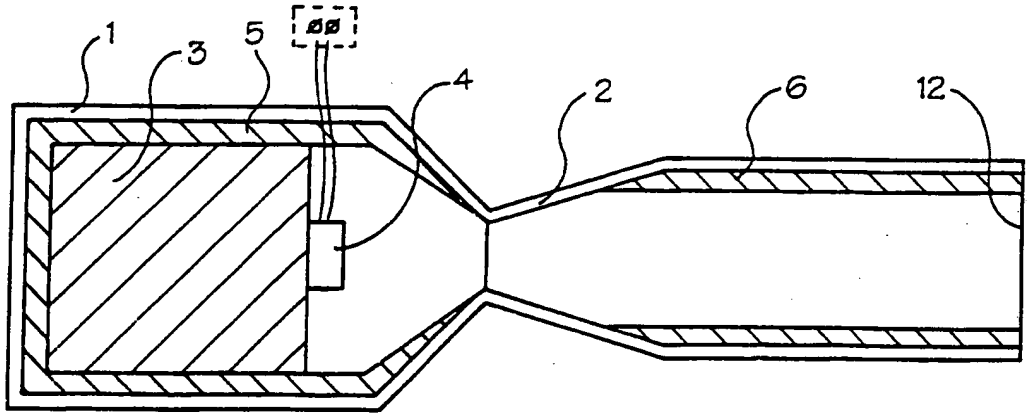

(57) Abstract

The present invention provides a fire extinguishing method and apparatus. The fire extinguishing apparatus includes a pyrotechnical charge (3), an ignition agent (4) for remotely igniting the pyrotechnical charge, and a nozzle (6) through which an aerosol fire extinguishing agent flows. The pyrotechnical charge is comprised of salts of alkali and alkali-earth metals or transition group metals which, upon ignition, form combustion products in the form of ultra dispersed condensed particles. The ultra-dispersed condensed particles break the fire chain mechanism by recombining with active radicals.

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FIRE EXTINGUISHING METHOD AND APPARATUS

Background of the Invention

The invention relates to fire extinguishing methods and apparatuses which are based on the use of pyrotechnical mixtures as combustion inhibitors that are introduced into the volume being protected.

A known method of fire extinguishing is one in which an aerosol combustion inhibitor is introduced into the volume being protected using as the inhibitor a powder that partially decomposes in a thermite mixture and releases a gas phase which pseudoliquifies the fire extinguishing powder, thus increasing the pressure in the fire extinguisher body and thereby supplying powder as it exits into the volume being protected (1). As the the thermite mixture cools, the slag formed heats the fire extinguishing powder by heat transfer.

In this method the pyrotechnical mixture plays the role of producing pressure to eject the combustion inhibitor from the fire extinguisher.

Summary of the Invention

The purpose of this invention is to increase fire extinguishing efficiency, to produce fire extinguishing agents not requiring periodic inspection of their condition, and to improve reliability and service.

This purpose is attained in that the fire extinguishing method introducing an aerosol combustion inhibitor using a pyrotechnical mixture, following the invention, uses as the combustion inhibitor the combustion products of the pyrotechnical mixture which are released in the form of an ultra- or a highly-dispersed condensed phase, containing salts of alkali and alkali-earth metals or transition group metals.

The aerosol mixture is cooled before being introduced into the volume being protected.

Chemical combustion inhibitors in case of fire are introduced into the volume being protected in the form of an aerosol mixture, including gaseous compounds--combustion

inhibitors--as well as ultra-dispersed condensed particles, which as a result of large surface energy are also effective combustion inhibitors. The indicated aerosol mixture may be made in various ways. The first way consists of burning pyrotechnical compositions which include elements that form compounds in the combustion process--combustion inhibitors. The second way consists of burning a pyrotechnical composition which includes combustion inhibitors as additional agents, and the third way is to produce combustion products containing ultra-dispersed condensed particles.

The aerosol mixture is also produced by introducing aqueous solutions of combustion inhibitors into the flow of hot gases, which already contain particles of substances that are inhibitors.

The apparatus for this invented fire extinguishing method, which in itself is also an invention, has a body with a nozzle and is characterized in that the body has a pyrotechnical charge, supplied with a remote ignition agent, and there are means for heatproofing the body and reducing the temperature of the gas-aerosol mixture through the use of a heatproof lining of the body and apparatus nozzle.

To improve cooling efficiency the apparatus is supplied with air-injected packing of the nozzle or with a tank containing water or aqueous solutions of combustion inhibitors, having a connection to the body and nozzle.

Brief Description of the Drawings

The construction of the invented apparatus is shown in the drawings in which Figure 1 gives a general view of the apparatus, Figure 2 shows the apparatus with the air-injected coolant packing, and Figure 3 shows the apparatus with a liquid coolant system.

Detailed Description of the Preferred Embodiments

This invention is based on the fact that with the introduction of organic substances of an aerosol mixture into the combustion zone that contain combustion inhibitors and solid particles, the probability of forming a break in the chain mechanism increases substantially in the combustion

zone of active radicals (active centers) due to their recombination according to the scheme $CH_3 + CH_3 \rightarrow C_2H_6$ or $CH_3 + CH \rightarrow CH_4$ and so forth, and also due to their retention on the aerosol surface. Each aerosol particle fulfills the role of a condenser of energy, released during the recombination reaction of the active radicals. In the absence of energy dissipation an aerosol particle can provide a specific number of recombinations, depending on the mass of the particle and its heat capacity. The inhibiting properties grow with the reduction of aerosol particle sizes, however, the presence in the combustion zone of powerful convective flows places limitations on the possibility of such a reduction.

In addition to solid phase sizes, the magnitude of the aerosol surface energy is determined by the energy of the crystal lattice and the presence of a defective structure on its surface or close to it.

This method allows for the use of the most diverse combustion inhibitors. Salts and hydroxides of alkaline metals have the best inhibiting properties. Metal compounds of the alkali-earth and transitional groups have good inhibiting properties.

Also, practically any pyrotechnical compositions whose combustion products contain ultra-dispersed condensed particles are acceptable in this invention.

The table 1 forming a part of this disclosure presents pyrotechnical compositions which were tested and showed favorable results.

The compositions numbered 1-3 in the table are low-energy compositions that make it possible to simplify the solution to the cooling problem of a gas-aerosol mixture.

The compositions numbered 4-8 in the table are characterized by the use of energy additions such as P and Mg. Al and Fe can also be used, but the ignition of the compositions becomes more complicated.

The minimum aerosol flow rate is 10 to 100 g/m^3 and greatly depends on the degree of cooling and the intensity

of aerosol delivery in the volume being protected, and also depends on the character and degree of openness of the volume being protected and the type of fire. Maximum intensification of the delivery process is desirable; otherwise the processes of particle growth and agglomeration substantially worsen the aerosol inhibiting properties.

The invention is illustrated by the following examples.

Example 1.

As a test, a chamber measuring 2.0 x 2.0 x 2.9 m was used in which the following sources of fire were arranged: a) a pan with an 0.2 m^2 area and 10 liters of kerosene and b) a fire of firewood weighing 5 kg and rags (1.5 kg), covered with kerosene (Class A and C fires). One pyrotechnical charge, whose composition corresponded to the one given under No. 5 in Table 1 with a weight of 900 g, was placed in the chamber. The fire sources were ignited with a torch, and the charges were remotely ignited with an electric pulse. Ignition time of the fire sources was 3 min. Operating time of the charge was 85 sec. Extinguishing of the fire sources took place at the 70th second, that is, before completion of the charge operation.

Example 2.

As a test a cylindrical chamber measuring 5 m in diameter and 1.5 m in height was used. A 1 m layer of water was poured into the chamber, but not on a 1.5 - 2 cm. thick layer of condensate. The condensate was lit with a torch. Extinguishing was accomplished by two devices, each of the type as shown in Figure 3, into each of which were placed three tablets, each tablet comprising either the pyrotechnical composition number 2 or 6 as shown in Table 1. The mass of each tablet was 90 g. The tablets were ignited with an electrical pulse. Extinguishing was achieved in multiple tests in 20-25 sec, and no repeated ignition was observed. Other examples are presented later in the discussion relating to an apparatus for implementation of the present invention of the method.

As Example 1 shows, realization of this method is also feasible without the use of special constructive solutions, by using simple combustion of appropriate compositions that contain either elements formed in the process of compound burning--combustion inhibitors, or earlier prepared inhibitors, but it is more effective to carry out this process with the use of apparatus made according to the invention described.

While there is a known fire extinguishing apparatus containing a body with a pyrotechnical charge and an outlet nozzle 1, the known apparatus does not provide effective fire extinguishing because this known fire extinguishing apparatus is not an aerosol generator. The proposed apparatus in essentially an aerosol generator. Figure 1, 2 and 3 show variants of the apparatus. The apparatus contains body 1, nozzle 2, pyrotechnical composition 3 arranged in the body, and remote control ignition devices 4. The body has a heat protective lining 5.

Various configurations of the apparatus provide for cooling of the gas-aerosol mixture. In the first variant (Figure 1), the inner surface of the nozzle also has lining 6, in the second case (Figure 2), the nozzle has air-ejected packing 7 with holes for air intake 8 and in the third case (Figure 3)--the tank for the coolant liquid is connected to the body and nozzle through openings 10 and 11. Opening 11 has a sprayer for spraying the liquid. Self-destructing diaphragm 12 is at the nozzle outlet.

Body 1 acts as a combustion chamber and lining for making the pyrotechnical charge airtight. The body makes it possible to guarantee a 10 to 12 year storage period for the charges with practically no preventive maintenance. The operating pressure in the combustion chamber is not high, on the order of 1.5 to 2 atm, thereby ensuring high work safety.

The lining 5, first of all, protects the body from heating up and ensures a maximum temperature of 60 to 160°, and secondly (the same as the lining of nozzle 6) additionally reduces the temperature of the gas-aerosol

mixture due to dilution of the gas aerosol mixture with the gaseous heat decomposition products of the lining. Thus, a temperature not higher than 300° can be maintained, that is, a temperature typically lower than the ignition temperature of organic compounds. In addition, the presence of CO_2 and H_2O in the lining decomposition products improves the fire extinguishing properties of the mixture.

Ignition device 4 represents a well known means for producing a heat pulse on command from the control sensors of a fire prevention defense system, and for this reason the device is not examined in detail here.

Operation of the apparatus shown in Figure 1 does not require any special explanation. However, it is noted that pyrotechnical charge 3 is ignited by a heat pulse developed by ignition device 4, and ensures a mass release of aerosol mixture in the combustion process due to use of the suggested compositions; this mixture is ejected through nozzle 2 into the volume being protected, thus ensuring suppression of the fire source because of intensive inhibition of active radicals in the combustion zone.

In using air-injected packing 7 (Figure2) for additional cooling of the gas-aerosol mixture, ejection of air takes place through opening 8 by means of the flow of the gas-aerosol mixture. Because the volume of ejected air is entirely determined by the flow rate of the gas-aerosol mixture and therefore by the relatively limited pressure (2 atm) in the combustion chamber (apparatus body), the possibilities of pure ejection cooling are limited and it is appropriate to combine cooling with the use of linings.

In contrast to those examined above, use of an apparatus with liquid cooling (Figure 3) of the gas-aerosol mixture is directed toward large apparatuses. Gases, entering volume 9 from the combustion chamber through valve 10, produce excess pressure which ensures ejection of the fluid from the volume through sprayer 11 in the nozzle.

Use of such a variant of the apparatus is feasible in three situations:

1. when pure water is used as the cooling liquid,
2. when aqueous solutions of combustion inhibitors are used as the liquid,
3. when combustion inhibitor inhibitors are the only source of cooling liquid, and formation of the gas-aerosol mixture takes place completely outside the combustion zone of the pyrotechnical charge, which in this case may be made of standard powders (mixed, pyroxylin, ballistite).

Table

Composition No.	Composition	Temperature of Burning T_r (K°)
1	20% C_3H_5O + 80% $KCLO_4$	2723
2	20% C_3H_5O + 50% $KCLO_4$ + 30% KNO_3	2238
3	20% C_3H_5O + 80% $K_2Cr_2O_7$	1837
4	8% P + 22% $KCLO_4$ + 60% KNO_3 + 10% C_3H_5O	1989
5	7% Mg + 48% KCO_4 + 30% KCL + 15% C_3H_5O	2444
6	10% Mg + 12% $KCLO_4$ + 60% KNO_3 + 18% C_3H_5O	2054
7	7% Mg + 48% $KCLO_4$ + 30% $K_2Cr_2O_7$ + 15% C_3H_5O	2437
8	10% Mg + 10% $KCLO_4$ + 50% KNO_3 + 15% $K_5P_3O_7$ + 15% C_3H_5O	1757

We claim:

1. Method for extinguishing fire by introducing into the volume being protected an aerosol combustion inhibitor using a pyrotechnical mixture is characterized in that the combustion products of a pyrotechnical mixture are used as a combustion inhibitor and these products are released in the form of an ultra- or highly-dispersed condensed phase, containing salts of alkali and alkali-earth metals or transition group metals.

2. Method in Paragraph 1 is characterized in that the aerosol mixture is cooled before being introduced into the volume being protected.

3. Fire extinguishing apparatus including a body with a pyrotechnical charge and outlet nozzle is characterized in that it is supplied with a cooling unit with a connection to the nozzle and an agent for remote ignition of the pyrotechnical charge, and the inner surface of the body is made in the form of a lining.

4. Apparatus in Paragraph 1 is characterized in that the cooling unit is made in the form of a cylinder with a lining.

5. The apparaus in Paragraph characterized in that the cooling unit is made in the form of air injected packing.

6. Apparatus in Paragraph 1 characterized in that the cooling unit is made in the form of a tank filled with liquid coolant connected to the body.

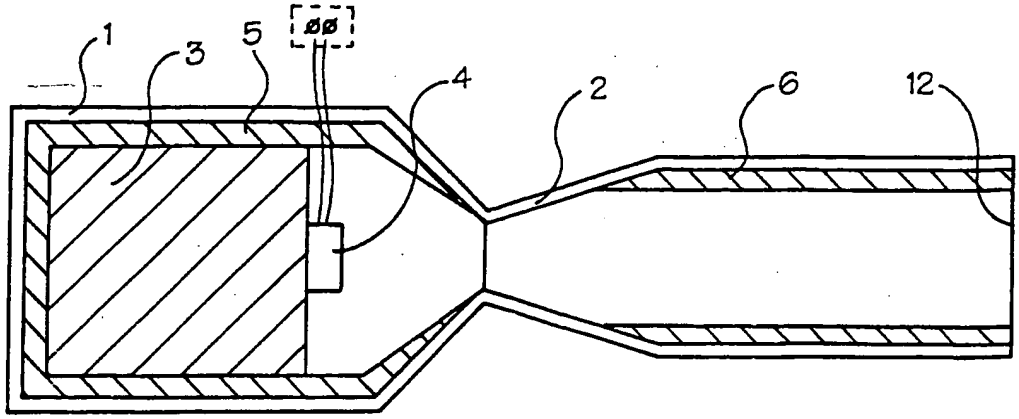

Fig. 1

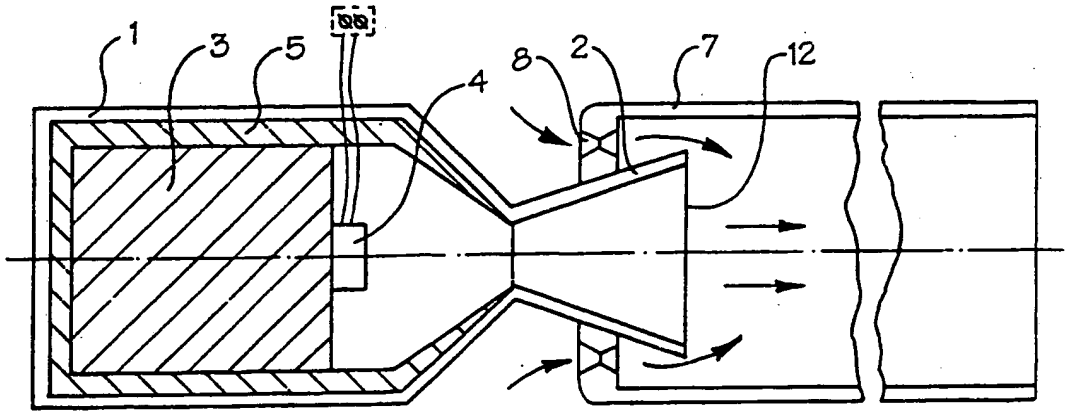

Fig. 2

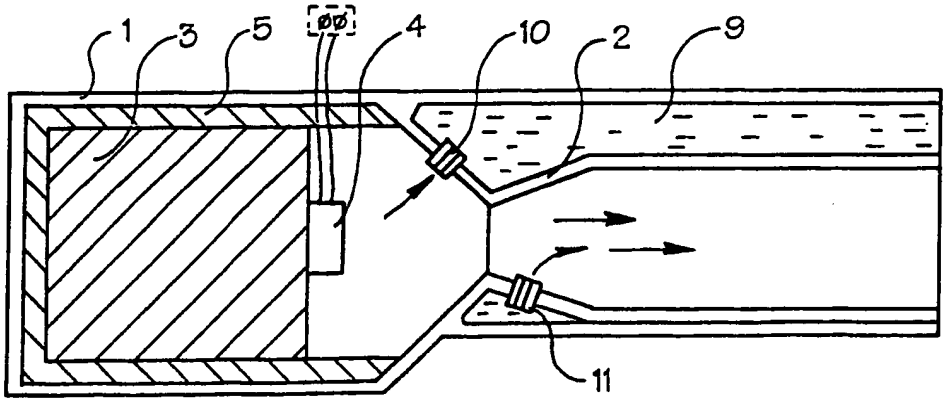

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/01234

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A62C 2/00
US CL :169/46
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 169/46, 12, 44, 70, 84, 30, 28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,616,859 (Shay et al.) 02 November 1971	NONE
A	US, A, 3,407,880 (Davis) 29 October 1968	NONE
A	US, A, 2,091,197 (Edmundson) 24 August 1937	NONE
A	SU, A, 1,475,685 (Dnepr Agric Inst) 30 April 1989	NONE
A	SU, A, 860,773 (Dnepr Agric Inst) 07 September 1981	NONE
A	SU, A, 1,630,840 (Mine Safety Res Inst) 28 February 1991	NONE
A	SU, A, 1,266,549 (Zakhmatov) 30 October 1986	NONE

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search
13 July 1993

Date of mailing of the international search report
14 JUL 1993

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/01234

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.: 5
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

the claim dependency is not specified. Therefore, it is impossible to determine the scope of the claim.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.